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(72) Inventors INDRAVADAN SHANTILAL SHAH
ALEXANDER KIRSCHNER

(54) GAS SCRUBBER

(71) We, CHEMICAL CONSTRUCTION CORPORATION, a Corporation organized under the laws of the State of Delaware, United States of America, of 320 Park Avenue, New York, 22, State of New York, United States of America, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to gas scrubbers and particularly to a downward flow venturi gas scrubber with a throat approach section comprising one or more conical baffles onto which liquid can be flowed.

These scrubbers are used to scrub gas streams with a liquid, to remove entrained solid particles or liquid droplets, or to selectively remove a gaseous or vaporous component. The invention is particularly applicable to the scrubbing of waste or stack gases with water or an aqueous solution, to remove impurities such as fly ash or sulfur dioxide, and thereby prevent air pollution.

Numerous types of devices have been suggested in the prior art, for the scrubbing of a gas stream with a liquid solution. One of the most important types of device employed for this purpose is a venturi scrubber, which accelerates the gas stream to high velocity in a venturi-type passage and projects the scrubbing liquid into the high velocity gas stream at or adjacent to the throat of the venturi. Numerous improvements in the basic venturi scrubber have been developed, as shown in U.S. Patents Nos. 3,440,803; 3,353,803; 3,262,685; 3,215,415; 3,057,605 and 2,883,167 and Canadian Patent No. 693,349. The annular venturi configuration useful in scrubbing large volumes of gas with low pressure drop is shown in German Patent Application D.O.S. 2,029,088 published Dec. 12, 1971 and German Patent Application D.O.S. 2,013,192 published Sept. 19, 1970 and U.S. Patents Nos. 3,317,197 and 3,085,793. In certain of these patents, a venturi configuration is shown in which a projection lip is provided at the base of the approach or converging section of the venturi, i.e., at the entry to the venturi throat, for projecting downflowing scrubbing liquid into the gas stream. This lip thus is of the same diameter as the throat or is of a diameter that the edge lies within the throat dimension.

According to the invention there is provided a downward flow venturi gas scrubber with a convergent throat approach section formed by one or more conical baffles onto and on which liquid can be flowed in which there is provided an annular liquid projection lip upstream of the throat on at least one baffle below the inlet for liquid which lip has an outer perimeter which is contiguous along the whole of its length with the baffle and which lip has an internal diameter greater than the diameter of the venturi throat.

Thus, a modified venturi scrubber is provided, in which the scrubbing liquid flows downwards on the wall of the converging approach section for projection into the gas stream within the throat section. Improved results are generally attained by the provision of a projection lip within the approach section and spaced above the throat section, with the lip having greater dimension or diameter than the throat itself. In a preferred embodiment, an annular venturi configuration is provided, in which a central conical baffle is also provided with a projection lip which is spaced above the lower terminus of the conical baffle and has an outer dimension less than the dimension of the base of the conical baffle. The term conical baffle as applied to the approach section encompasses both conical and inverted frusto-conical baffles as illustrated.

There are several salient advantages to the apparatus of the present invention, as contrasted to prior art devices in which a projection lip is disposed at the base of the approach or converging section and therefore at the top of the throat section. The apparatus of the present invention produces an effectively longer zone of high velocity turbulence due to earlier distribution of liquid, assuming an equal trajectory of liquid. However since the liquid is introduced at an upper plane where a lower gas velocity occurs than

at the throat itself, greater distances of penetration into the gas stream occurs, resulting in a greater effective length of high velocity turbulent zone. In effect, one of the advantageous results of the invention is that a uniformly turbulent zone is established throughout the length of the throat. In addition, due to this greater penetration, a wider throat may be used for any given gas velocity than is possible in prior art configurations. Another important factor and advantage is the influence of the upwardly displaced projection lip in breaking cohesive contact between the wet approach cone and the flowing liquid. This provides more effective fragmentation of the scrubbing liquid, and minimizes short circuiting of a scrubbing liquid film or layer along the surface of the throat.

Preferred embodiments of the invention are illustrated in the accompanying drawings, in which:

Figure 1 is a sectional elevation view of a generalized embodiment of the invention,

Figure 2 is a sectional elevation view of a preferred embodiment of the invention as applied to an annular venturi scrubber.

Figure 3 is a plan view of Figure 2, taken on section 3-3, and

Figure 4 shows typical throat inserts, applicable to the device of Figure 1 or the approach members of Figure 2.

Referring now to Figure 1, which shows a typical application of the device of the invention to the scrubbing of a flue gas or other waste gas derived from a steam power boiler or the like, fuel stream 1, which may consist of any suitable gaseous, liquid or solid fuel such as a fluid hydrocarbon or coal, is passed together with combustion air stream 2 into steam power boiler 3, for the generation of high pressure steam for electricity production. Solid ash, if present, is removed from unit 3 via stream 4, and the generated combustion flue gas containing entrained solid fly ash and sulfur dioxide is also removed from unit 3 via outlet stack 5, which in typical prior art practice discharges the flue gas to the atmosphere with resultant air pollution. In the present invention, the flue gas passes from stack 5 via stream 6, which flows downwards through the vertically oriented conduit 7 and into the apparatus of the present invention.

Conduit 7 extends downwards and connects with the annular collar or trough 8, which connects conduit 7 with the inverted frusto-conical approach or converging baffle 9, which defines the converging section of the venturi passage. The annular tangential nozzles 10 are provided in the collar 8, and serve to pass scrubbing liquid streams such as stream 11 onto the inner surface of baffle 9, so that the scrubbing liquid flows downwards on the inner surface of baffle 9 in a whirling spiral flow path. Stream 11 may consist of water or a suitable aqueous alkaline solution which dissolves sulfur dioxide, in addition to scrubbing fly ash from the gas stream.

The scrubbing liquid film or layer which flows downwards on the inner surface of baffle 9 is projected by lip 12 into the accelerated gas stream, which flows at high velocity through the lower portion of the venturi passage defined by baffle 9 and the cylindrical throat section baffle 13, which depends downwards from baffle 9. The lip 12 is a generally horizontal ring-shaped annular member, which extends inwards from the inner surface of baffle 9 and terminates at a circular inner perimeter which is of greater diameter than the diameter of baffle 13, so that a convergence of a gas flow passage takes place between lip 12 and baffle 13. The liquid which is projected into the gas stream by lip 12 is dispersed into small droplets above and at the entry into the throat section defined by baffle 13, and effective scrubbing of the highly accelerated gas stream takes place within the throat section.

The resulting mixture of dispersed liquid droplets in the gas stream next flows downwards through the frusto-conical baffle 14, which depends downwards from baffle 13 and is provided to promote recovery of gas pressure head without turbulence, thus providing a minimum overall loss of gas pressure or pressure drop through the device. The gas-liquid mixture next flows through cylindrical conduit 15, which depends from baffle 14 and conducts the mixture via stream 16 to the gas-liquid separator 17, which is a baffled or cyclonic vessel for the separation of scrubbed gas from the entrained liquid phase. The separated scrubbing liquid, now containing fly ash and sulfur dioxide removed from the flue gas, is removed from separator 17 via stream 18, which is discharged to waste or processed for recovery of dissolved sulfur dioxide or sulfites. The scrubbed flue gas is discharged from unit 17 via stream 19, which may now be safely discharged to the atmosphere without causing air pollution.

Referring now to Figure 2, a preferred embodiment of the invention is shown, in which an annular venturi scrubber is provided to attain the scrubbing of large gas volumes with low pressure drop. Waste or flue gas stream 20, which may be similar to stream 6 described supra, is passed downwards through the vertically oriented cylindrical conduit 21. An outer cylindrical conduit 22 is disposed about the lower end of conduit 21, and the top of conduit 22 is connected with conduit 21 by a fluid-impervious baffle or other suitable connection. A plurality of horizontal liquid dis-

charge pipes 23 are tangentially disposed adjacent to the base of conduit 22, and tangentially discharge the scrubbing liquid streams 24 within conduit 22 and at the top of the inverted frusto-conical baffle 25, which depends downwards from conduit 22. The scrubbing liquid flows downwards on the inner surface of conduit 25 in a spiral or whirling flow path.

An annular support member 26, which is of a general configuration similar to lip 12 described supra, is disposed on the inner surface of baffle 25, and member 26 extends inwards and supports the annular liquid projection lip 27, which is a generally flat ring-shaped annular baffle or lip which is preferably removable and is mounted on or rests on member 26. An inverted frusto-conical baffle 28 extends downwards and inwards from the lower surface of member 27, and baffle 28 terminates at a lower circular perimeter which is of lesser diameter than the diameter of the inner perimeter of member 27, so that baffle 28 extends further into the gas stream than baffle 27. The down-flowing liquid stream on the surface of baffle 25 is projected into the gas stream by lip 27 above baffle 28, and the liquid is thereby dispersed into the high velocity gas stream as small discrete droplets and particles of liquid.

A central conical baffle 29 is mounted or otherwise disposed coaxially within baffle 25, with the apex of baffle 29 extending upwards and opposed to downwards gas flow from conduit 21. An annular support 30 consisting generally of a flat horizontal ring extends outwards from the side wall of baffle 29, and suport 30 will preferably be spaced opposite to and on the same vertical elevation as support 26. The support 30 will be of a general configuration similar to lip 12 described supra, except that support 30 extends outwards from the conical surface 29. Member 30 extends outwards and supports the annular liquid projection lip 31, which is a generally flat ring-shaped annular baffle or lip which is preferably removable and is mounted on or rests on member 30. A frusto-conical baffle 32 extends downwards and outwards from the lower surface of member 31, and baffle 32 terminates at a lower circular perimeter which is of greater diameter than the outer perimeter of member 31, so that baffle 32 extends further into the gas stream than baffle 31.

Scrubbing liquid stream 33 is pumped via pump 34 as stream 35 through pipe 36, which extends through members 22 and 21 and terminates centrally with a vertically downward extension, so that pipe 36 discharges scrubbing liquid centrally at the apex of baffle 29, and the scrubbing liquid flows downwards on the outer surface of baffle 29 and is projected outwards into the gas stream by lip 31. The lips 27 and 31 thus project scrubbing liquid into the annular venturi passage which is generally defined by the convergence of baffles 25 and 29, together with the convergence of baffles 28 and 32. The annular venturi passage is further defined by the vertical cylindrical baffle 37, which depends downwards from baffle 25, and the vertical cylindrical baffle 38, which depends downwards from the base of baffle 29. The baffles 37 and 38 define the throat section of the annular venturi passage. An inverted conical baffle 39 preferably depends downwards from baffle 38, and a frusto-conical baffle 40 preferably depends downwards from baffle 37, so that the baffles 39 and 40 define the diverging outlet section of the annular venturi passage. The gas stream is accelerated to high velocity in the annular venturi passage, and the liquid films or layers projected into the gas stream by lips 29 and 31 are dispersed into a plurality of droplets in and above the throat section of the annular venturi passage, so that effective gas scrubbing is accomplished with low pressure drop.

The resulting mixture of scrubbed gas and entrained liquid droplets flows downwards from the annular venturi passage into a primary liquid separation chamber generally defined by vertical cylindrical conduit 41, which depends downwards from baffle 40. Separated liquid collects in the bottom of the chamber as pool 42, and may be continuously or intermittently withdrawn. The scrubbed gas stream, which may contain residual entrained liquid droplets, is removed from the device via duct 43 as stream 44, which may be processed in a manner similar to stream 16 as described supra. The excess liquid from pool 42 is withdrawn via duct 43 as an overflow stream of excess liquid.

Figure 3 is a sectional plan view of Figure 2, taken on section 3-3, and shows the coaxial and concentric arrangement of the various apparatus elements in circular plan section, as well as various appurtenances. The scrubbing liquid streams 45 pass via pumps 46 as streams 47 through pipes 23, for tangential discharge onto the upper surface of baffle 25.

Figure 4 is a sectional isometric view of the added removable baffles provided in the approach section of the annular venturi passage of Figure 2, and the structures illustrated in Figure 4 may be designated as removable throat inserts. The throat insert element formed by baffles 27 and 28 may also be utilized in some cases in the device of Figures 1, in which case the baffle 27 would rest or be mounted on lip 12, with the liquid streams 11 being projected into the gas stream by baffle 27.

Numerous alternatives within the scope of the present invention besides those men-

tioned supra will occur to those skilled in the art. The throat inserts defined respectively by baffles 27 and 28, and baffles 31 and 32, may be omitted from the device of Figure 2 in some instances, in which case the liquid films flowing downwards on the surfaces of baffles 25 and 29 would be projected into the accelerated gas stream by lips 26 and 30. In some cases, when gas pressure drop is not a major consideration, a modified venturi arrangement consisting primarily of an approach or converging section may be provided in practice, in which case certain baffles such as 14, or 37, 38, 39 and 40, after the throat may be omitted, with the gas-liquid mixture discharging into a lower chamber from the converging passage. The device of the present invention is applicable to the scrubbing of various types of process or waste gas streams, such as incinerator off-gases or the tail gas from chemical processes such as sulfuric acid manufacture. A bull nozzle, or a series of nozzles, may be provided in practice above or within the approach sections of the venturi devices of the present invention, to spray scrubbing liquid downwards into the throat section of the device. The device of Figure 2 may be modified in practice, by the provision of an annular ring-shaped baffle having an upper angular projection within the annular throat section, so as to provide two concentric annular venturi passages, as described in German Patent Application D.O.S. 2,013,192 mentioned earlier.

WHAT WE CLAIM IS:—

1. A downward flow venturi gas scrubber with a convergent throat approach section formed by one or more conical baffles onto and on which liquid can be flowed in which there is provided an annular liquid projection lip upstream of the throat on at least one baffle below the inlet for liquid which lip has an outer perimeter which is contiguous along the whole of its length with the baffle and which lip has an internal diameter greater than the diameter of the venturi throat.

2. A scrubber according to claim 1, in which the venturi comprises, as approach section conical baffle an inverted frustoconical baffle, as throat section a cylindrical throat and also comprises a lower frustoconical baffle, and one or more tangential liquid inlets on the approach section to provide swirling liquid flow, the lip having an internal diameter greater than the throat.

3. A scrubber according to claim 2, in which an annular venturi is provided by the external surfaces of a central conical baffle, the lower edge of which is at the entry to the throat and from which lower edge there is a cylindrical section followed by a lower inverted conical baffle.

4. A scrubber according to claim 3, in which an inlet for liquid is provided for the central conical baffle which baffle has an external liquid projection lip with an external diameter less than the internal diameter of the throat section at the central conical baffle.

5. A scrubber according to either of claims 3 or 4, in which each liquid projection lip is a ring mountable externally on the central conical baffle in the approach section and having a further conical baffle extending downwardly from the edge thereof.

6. A scrubber according to claim 5, in which each further conical baffle extends from a point on the lower side of the ring spaced from the perimeter of the baffle.

7. A scrubber according to either of claims 5 or 6, in which each approach baffle has a support for the ring which support is an annular lip adapted to serve as a projection lip in the absence of the ring.

8. A downward flow venturi gas scrubber according to claim 1, substantially as hereinbefore described in the specific embodiment illustrated in Figure 1 or the specific embodiment illustrated in Figures 2, 3 and 4.

LANGNER PARRY,
Chartered Patent Agents,
Chichester House,
278-282 High Holborn,
London, W.C.1,
Agents for the Applicants.

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1328990 COMPLETE SPECIFICATION
4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

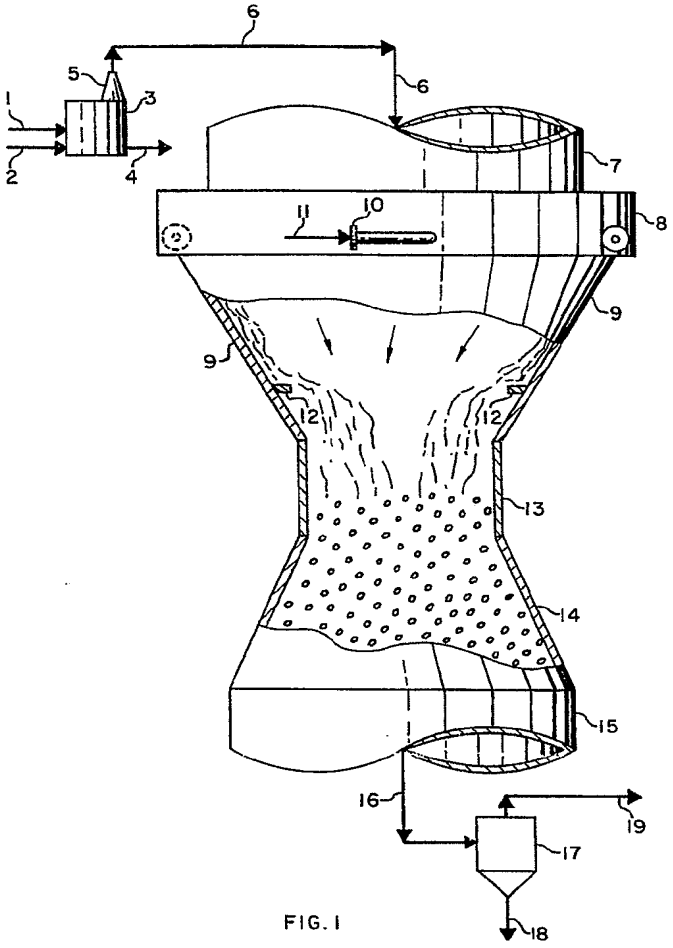

FIG. 1

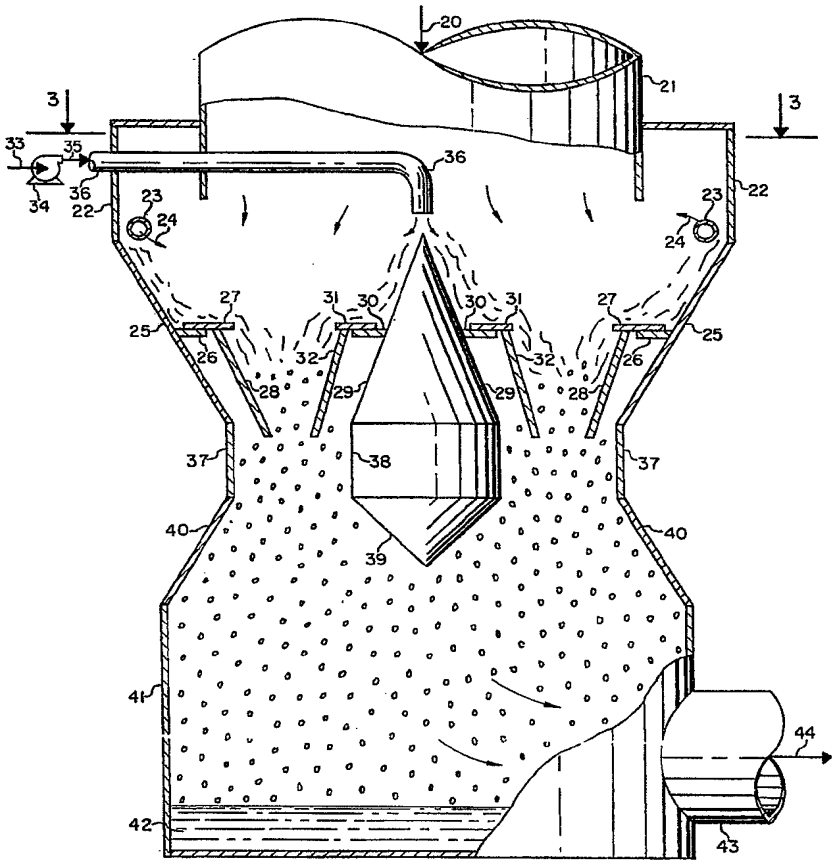

FIG. 2

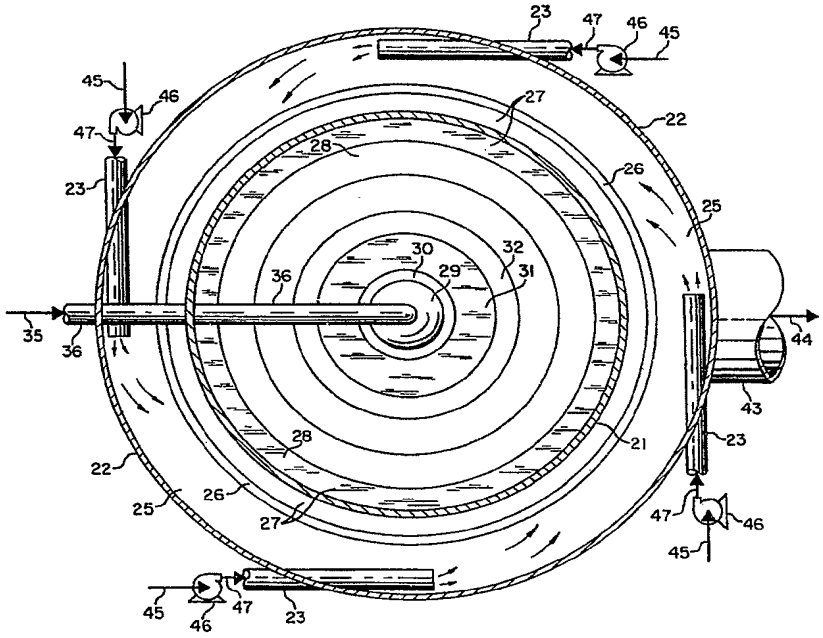

FIG. 3

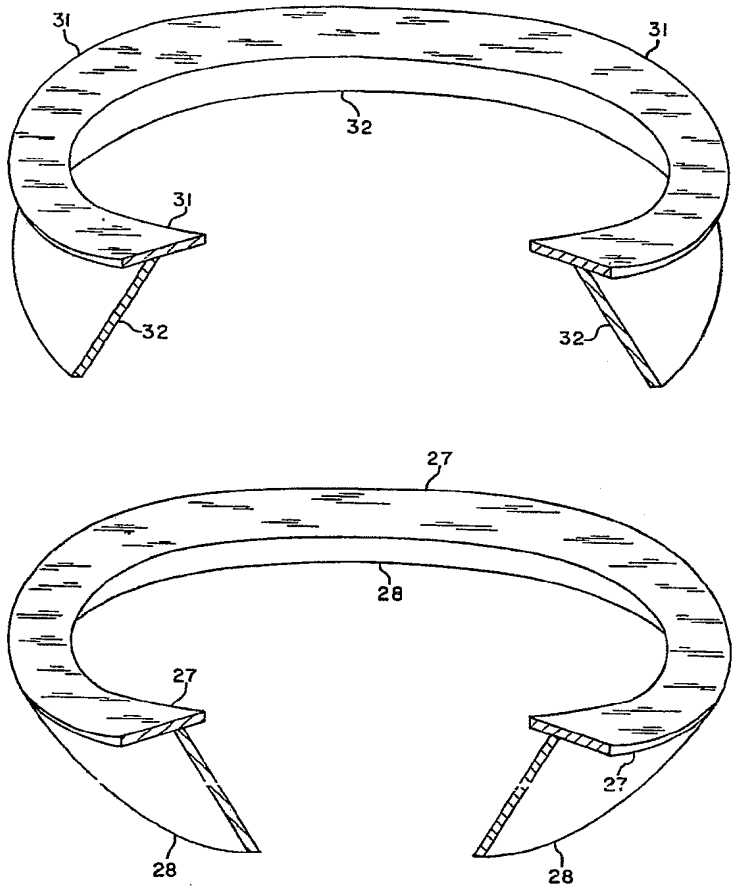

FIG. 4